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RESEARCH LABORATORY

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NATIONAL ENVIRONMENTAL RESEARCH CENTER

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16. ABSTRACT

Annual total phosphorus and total nitrogen loadings to the lake were estimated and subdivided according to either point or non-point source origin. An assessment of the lake's trophic condition and limiting nutrient is also provided. All data collected by the U.S.E.P.A. National Eutrophication Survey during the one year study of the lake and its tributaries are included in the report.

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NATIONAL EUTROPHICATION SURVEY

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REPORT

ON

OLIVER LAKE

LAGRANGE COUNTY

INDIANA

EPA REGION V

WORKING PAPER No. 339

WITH THE COOPERATION OF THE

INDIANA STATE BOARD OF HEALTH

AND THE

INDIANA NATIONAL GUARD

MARCH, 1976

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FOREWORD

The National Eutrophication Survey was initiated in 1972 in response to an Administration commitment to investigate the nationwide threat of accelerated eutrophication to fresh water lakes and reservoirs.

OBJECTIVES

The Survey was designed to develop, in conjunction with state environmental agencies, information on nutrient sources, concentrations, and impact on selected freshwater lakes as a basis for formulating comprehensive and coordinated national, regional, and state management practices relating to point-source discharge reduction and non-point source pollution abatement in lake watersheds.

ANALYTIC APPROACH

The mathematical and statistical procedures selected for the Survey's eutrophication analysis are based on related concepts that:

a. A generalized representation or model relating sources, concentrations, and impacts can be constructed.

b. By applying measurements of relevant parameters associated with lake degradation, the generalized model can be transformed into an operational representation of a lake, its drainage basin, and related nutrients.

c. With such a transformation, an assessment of the potential for eutrophication control can be made.

LAKE ANALYSIS

In this report, the first stage of evaluation of lake and watershed data collected from the study lake and its drainage basin is documented. The report is formatted to provide state environmental agencies with specific information for basin planning {§303(e)}, water quality criteria/standards review {§303(c)}, clean lakes {§314(a,b)}, and water quality monitoring {§106 and §305(b)} activities mandated by the Federal Water Pollution Control Act Amendments of 1972.

Beyond the single lake analysis, broader based correlations between nutrient concentrations (and loading) and trophic condition are being made to advance the rationale and data base for refinement of nutrient water quality criteria for the Nation's fresh water lakes. Likewise, multivariate evaluations for the relationships between land use, nutrient export, and trophic condition, by lake class or use, are being developed to assist in the formulation of planning guidelines and policies by EPA and to augment plans implementation by the states.

ACKNOWLEDGMENT

The staff of the National Eutrophication Survey (Office of Research & Development, U. S. Environmental Protection Agency) expresses sincere appreciation to the Indiana State Board of Health for professional involvement, to the Indiana National Guard for conducting the tributary sampling phase of the Survey, and to those Indiana wastewater treatment plant operators who provided effluent samples and flow data.

The staff of the Division of Water Pollution Control, Indiana State Board of Health, provided invaluable lake documentation and counsel during the Survey, reviewed the preliminary reports, and provided critiques most useful in the preparation of this Working Paper series.

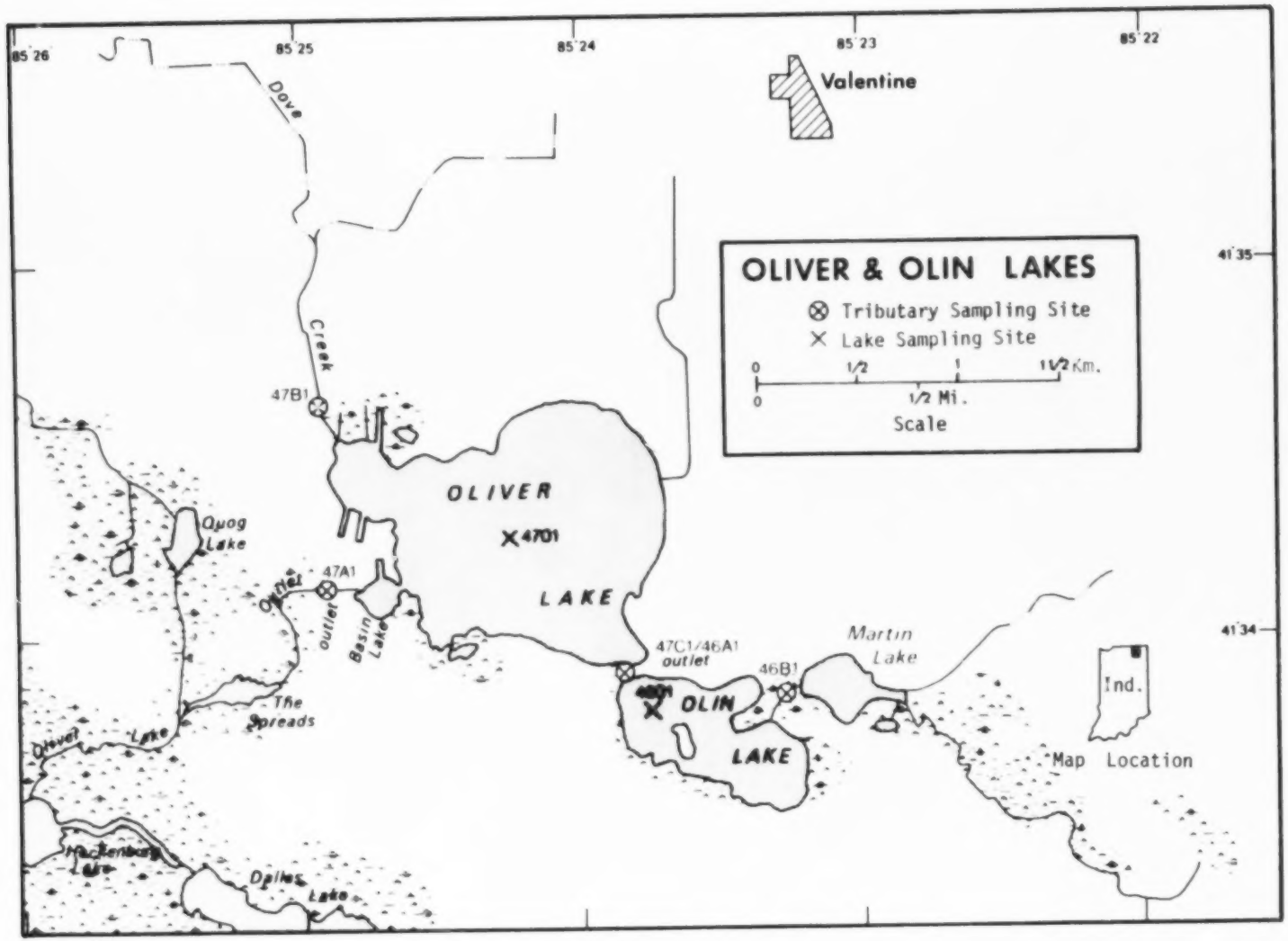
Major General Alfred F. Ahner, Adjutant General of Indiana, and Project Officers Lt. Colonel Charles B. Roberts (Retired) and Colonel Robert L. Sharp, who directed the volunteer efforts of the Indiana National Guardsmen, are also gratefully acknowledged for their assistance to the Survey.

NATIONAL EUTROPHICATION SURVEY

STUDY LAKES

STATE OF INDIANA

LAKE NAME	COUNTY
Bass	Starke
Cataract	Owen, Putnam
Crooked	Steuben
Dallas	LaGrange
Geist	Hamilton, Marion
Hamilton	Steuben
Hovey	Posey
James	Kosciusko
James	Steuben
Long	Steuben
Marsh	Steuben
Mississinewa	Grant, Miami, Wabash
Maxinkuckee	Marshall
Monroe	Brown, Monroe
Morse	Hamilton
Olin	LaGrange
Oliver	LaGrange
Pigeon	Steuben
Sylvan	Noble
Tippecanoe	Kosciusko
Versailles	Ripley
Wawassee	Kosciusko
Webster	Kosciusko
Westler	LaGrange
Whitewater	Union
Winona	Kosciusko
Witmer	LaGrange


85°26
85°25
85°24
85°23
85°22
41°35
41°34
Valentine
Dove
Creek
47B1
OLIVER
X4701
LAKE
Quog
Lake
47A1
Outlet
outlet
Basin
Lake
47C1/46A1
outlet
46B1
Martin
Lake
OLIN
LAKE
The
Spreads
Ind.
Map Location
OLIVER & OLIN LAKES
⊗ Tributary Sampling Site
× Lake Sampling Site
0 1/2 1 1½ Km.
0 1/2 Mi.
Scale

OLIVER LAKE

STORET NO. 1847

I. CONCLUSIONS

A. Trophic Condition:

Survey data indicate that Oliver Lake is mesotrophic. It ranked second in overall trophic quality when the 27 Indiana lakes sampled in 1973 were compared using a combination of six parameters*. None of the other lakes had less median total phosphorus, three had less median dissolved phosphorus, 14 had less median inorganic nitrogen, none of the others had less mean chlorophyll a, and only three had greater mean Secchi disc transparency. Marked depression of dissolved oxygen with depth occurred in August and October.

Survey limnologists noted submerged and emergent macrophytes in the shallows but no concentrations of algae.

B. Rate-Limiting Nutrient:

The algal assay results indicate that Oliver Lake was phosphorus limited at the time the sample was collected (05/04/73). The lake data indicate phosphorus limitation at all sampling times.

C. Nutrient Controllability:

1. Point sources--No known municipal or industrial point sources impacted Oliver Lake during the sampling year. Lakeshore

* See Appendix A.

septic tanks were estimated to have contributed 6.2% of the input, but a shoreline survey would be needed to determine the significance of these sources.

The present phosphorus loading of 0.16 $g/m^2/yr$ is less than that proposed by Vollenweider (Vollenweider and Dillon, 1974) as an oligotrophic loading (see page 11). Because Oliver Lake is phosphorus limited, all phosphorus inputs should be held to a minimum to maintain the high trophic quality of this water body.

2. Non-point sources--Over 93% of the total phosphorus input to Oliver Lake came from non-point sources during the sampling year. The Olin Lake outlet contributed 29.2% and Dove Creek 25.0% of the input. The ungaged tributaries were estimated to have contributed 29.2% of the total phosphorus load.

II. LAKE AND DRAINAGE BASIN CHARACTERISTICS†

A. Lake Morphometry††:

1. Surface area: 1.50 kilometers^2.
2. Mean depth: 12.2 meters.
3. Maximum depth: 27.7 meters.
4. Volume: 18.300 x 10^6 m^3.
5. Mean hydraulic retention time: 2.3 years.

B. Tributary and Outlet:
(See Appendix C for flow data)

1. Tributaries -

Name	Drainage area (km^2)*	Mean flow (m^3/sec)*
Dove Creek	5.7	0.05
Olin Lake outlet	15.0	0.14
Minor tributaries & immediate drainage -	6.5	0.06
Total	27.2	0.25

2. Outlet -

Oliver Lake outlet	28.7**	0.25

C. Precipitation***:

1. Year of sampling: 111.6 centimeters.
2. Mean annual: 91.3 centimeters.

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† Table of metric conversions--Appendix B.
†† Winters, 1975.
* For limits of accuracy, see Working Paper No. 175, "...Survey Methods, 1973-1976".
** Includes area of lake; outflow adjusted to equal sum of inflows.
*** See Working Paper No. 175.

III. LAKE WATER QUALITY SUMMARY

Oliver Lake was sampled three times during the open-water season of 1973 by means of a pontoon-equipped Huey helicopter. Each time, samples for physical and chemical parameters were collected from a number of depths at one station on the lake (see map, page v). During each visit, a single depth-integrated (4.6 m to surface) sample was collected from the stations for phytoplankton identification and enumeration, and a similar sample was taken for chlorophyll *a* analysis. During the first visit, a single 18.9-liter depth-integrated sample was collected for algal assays. The maximum depth sampled was 24.4 meters.

The sampling results are presented in full in Appendix D and are summarized in the following table.

A. SUMMARY OF PHYSICAL AND CHEMICAL CHARACTERISTICS FOR OLIVER LAKE
STORET CODE 1847

	1ST SAMPLING (5/ 4/73) 1 SITES			2ND SAMPLING (8/ 6/73) 1 SITES			3RD SAMPLING (10/11/73) 1 SITES		
PARAMETER	RANGE	MEAN	MEDIAN	RANGE	MEAN	MEDIAN	RANGE	MEAN	MEDIAN
TEMP (C)	8.4 - 11.7	10.4	11.4	7.0 - 24.7	15.8	13.9	7.0 - 19.3	12.0	9.6
DISS OXY (MG/L)	9.8 - 10.7	10.4	10.5	1.0 - 8.2	4.9	5.0	0.2 - 9.4	3.5	0.8
CNDCTVY (MCROMO)	410. - 450.	433.	440.	298. - 402.	352.	352.	301. - 355.	327.	322.
PH (STAND UNITS)	8.1 - 8.5	8.3	8.3	7.4 - 8.4	7.9	7.7	7.3 - 8.5	7.7	7.4
TOT ALK (MG/L)	181. - 189.	183.	182.	156. - 188.	174.	185.	145. - 187.	168.	178.
TOT P (MG/L)	0.006 - 0.009	0.007	0.007	0.008 - 0.016	0.010	0.009	0.012 - 0.019	0.016	0.017
ORTHO P (MG/L)	0.002 - 0.002	0.002	0.002	0.002 - 0.005	0.004	0.004	0.012 - 0.015	0.014	0.014
NO2+NO3 (MG/L)	0.940 - 1.010	0.987	0.990	0.720 - 1.080	0.874	0.870	0.240 - 0.870	0.629	0.595
AMMONIA (MG/L)	0.040 - 0.060	0.044	0.040	0.040 - 0.100	0.063	0.060	0.030 - 0.400	0.104	0.050
KJEL N (MG/L)	0.300 - 0.300	0.300	0.300	0.200 - 0.800	0.371	0.300	0.400 - 0.900	0.512	0.450
INORG N (MG/L)	1.000 - 1.050	1.031	1.030	0.760 - 1.140	0.937	0.930	0.590 - 0.910	0.732	0.695
TOTAL N (MG/L)	1.240 - 1.310	1.287	1.290	1.120 - 1.550	1.246	1.170	0.960 - 1.370	1.141	1.145
CHLRPYL A (UG/L)	2.7 - 2.7	2.7	2.7	5.2 - 5.2	5.2	5.2	3.4 - 3.4	3.4	3.4
SECCHI (METERS)	3.4 - 3.4	3.4	3.4	1.8 - 1.8	1.8	1.8	3.0 - 3.0	3.0	3.0

B. Biological characteristics:

1. Phytoplankton -

Sampling Date	Dominant Genera	Algal Units per ml
05/04/73	1. Oocystis sp.	616
	2. Melosira sp.	590
	3. Fragilaria sp.	402
	4. Dinobryon sp.	289
	5. Cyclotella sp.	264
	Other genera	615
	Total	2,776
08/06/73	1. Stephanodiscus sp.	456
	2. Flagellates	178
	3. Oocystis sp.	79
	4. Peridinium sp.	40
	5. Gomphosphaeria sp.	40
	Other genera	158
	Total	951
10/11/73	1. Fragilaria sp.	53
	2. Dinobryon sp.	53
	3. Flagellates	53
	4. Gomphosphaeria sp.	35
	5. Dinoflagellates	35
	Other genera	158
	Total	387

2. Chlorophyll a -

Sampling Date	Station Number	Chlorophyll a (µg/l)
05/04/73	1	2.7
08/06/73	1	5.2
10/11/73	1	3.4

C. Limiting Nutrient Study:

1. Autoclaved, filtered, and nutrient spiked -

Spike (mg/l)	Ortho P Conc. (mg/l)	Inorganic N Conc. (mg/l)	Maximum yield (mg/l-dry wt.)
Control	<0.005	0.965	0.1
0.050 P	0.055	0.965	15.2
0.050 P + 1.0 N	0.055	1.965	17.6
1.0 N	<0.005	1.965	0.1

2. Discussion -

The control yield of the assay alga, Selenastrum capricornutum, indicates that the potential primary productivity of Oliver Lake was low at the time the sample was collected (05/04/73). A significant increase in yield resulted when only phosphorus was added, but the addition of nitrogen alone did not result in an increase in yield; hence, phosphorus limitation is indicated.

The lake data also indicate limitation by phosphorus; the mean inorganic nitrogen/orthophosphorus ratios were 52/1 or greater at all sampling times.

IV. NUTRIENT LOADINGS
(See Appendix E for data)

For the determination of nutrient loadings, the Indiana National Guard collected monthly near-surface grab samples from each of the tributary sites indicated on the map (page v), except for the high runoff months of February and March when two samples were collected. Sampling was begun in June, 1973, and was completed in May, 1974.

Through an interagency agreement, stream flow estimates for the year of sampling and a "normalized" or average year were provided by the Indiana District Office of the U.S. Geological Survey for the tributary sites nearest the lake.

In this report, nutrient loads for sampled tributaries were determined by using a modification of a U.S. Geological Survey computer program for calculating stream loadings*. Nutrient loads for unsampled "minor tributaries and immediate drainage" ("ZZ" of U.S.G.S.) were estimated using the nutrient loads, in $kg/km^2/year$, at station B-1 and multiplying by the ZZ area in km^2.

All estimated point-source phosphorus loads were reduced by 50% to adjust for the phosphate detergent ban in effect in Indiana since January, 1972.

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* See Working Paper No. 175.

A. Waste Sources:

1. Known municipal - None

2. Known industrial - None

B. Annual Total Phosphorus Loading - Average Year:

1. Inputs -

Source	kg P/ yr	% of total
a. Tributaries (non-point load) -		
Dove Creek	60	25.0
Olin Lake outlet	70	29.2
b. Minor tributaries & immediate drainage (non-point load) -	70	29.2
c. Known municipal STP's - None	-	-
d. Septic tanks* -	15	6.2
e. Known industrial - None	-	-
f. Direct precipitation** -	25	10.4
Total	240	100.0

2. Outputs -

Lake outlet - Oliver Lake outlet 110

3. Net annual P accumulation - 130 kg.

* Estimate based on 96 lakeshore dwellings and one camp; see Working Paper No. 175.
** See Working Paper No. 175.

C. Annual Total Nitrogen Loading - Average Year:

1. Inputs -

Source	kg N/yr	% of total
a. Tributaries (non-point load) -		
Dove Creek	5,505	23.4
Olin Lake outlet	9,000	38.3
b. Minor tributaries & immediate drainage (non-point load) -	6,280	26.7
c. Known municipal STP's - None	-	-
d. Septic tanks* -	1,095	4.7
e. Known industrial - None	-	-
f. Direct precipitation** -	1,620	6.9
Total	23,500	100.0

2. Outputs -

Lake outlet - Oliver Lake outlet 13,155

3. Net annual N accumulation - 10,345 kg.

D. Mean Annual Non-point Nutrient Export by Subdrainage Area:

Tributary	kg P/km^2/yr	kg N/km^2/yr
Dove Creek	11	966
Olin Lake outlet	5	600

* Estimate based on 96 lakeshore dwellings and one camp; see Working Paper No. 175.
** See Working Paper No. 175.

E. Yearly Loads:

In the following table, the existing phosphorus loadings are compared to those proposed by Vollenweider (Vollenweider and Dillon, 1974). Essentially, his "dangerous" loading is one at which the receiving water would become eutrophic or remain eutrophic; his "permissible" loading is that which would result in the receiving water remaining oligotrophic or becoming oligotrophic if morphometry permitted. A mesotrophic loading would be considered one between "dangerous" and "permissible".

Note that Vollenweider's model may not be applicable to water bodies with short hydraulic retention times.

	Total Phosphorus		Total Nitrogen	
	Total	Accumulated	Total	Accumulated
grams/m^2/yr	0.16	0.09	15.7	6.9

Vollenweider phosphorus loadings ($g/m^2/yr$) based on mean depth and mean hydraulic retention time of Oliver Lake:	
"Dangerous" (eutrophic loading)	0.44
"Permissible" (oligotrophic loading)	0.22

V. LITERATURE REVIEWED

Vollenweider, R. A., and P. J. Dillon, 1974. The application of the phosphorus loading concept to eutrophication research. Natl. Res. Council of Canada Publ. No. 13690, Canada Centre for Inland Waters, Burlington, Ontario.

Winters, John, 1975. Personal communication (lake morphometry). IN Div. Water Poll. Contr., Indianapolis.

VI. APPENDICES

APPENDIX A

LAKE RANKINGS

LAKE DATA TO BE USED IN RANKINGS

LAKE CODE	LAKE NAME	MEDIAN TOTAL P	MEDIAN INORG N	500-MEAN SEC	MEAN CHLORA	15- MIN DO	MEDIAN DISS ORTHO P
1805	CATARACT LAKE	0.05-	1.660	466.667	15.7--	15.000	0.013
1811	GEIST RESERVOIR	0.07-	1.080	472.500	45.950	11.600	0.00-
1817	JAMES LAKE	0.02-	1.030	434.000	11.533	15.000	0.00-
1827	MISSISSINEWA RESERVOIR	0.107	2.400	473.444	15.77-	15.000	0.02-
1828	MONROE RESERVOIR	0.02-	0.325	438.823	5.947	15.000	0.007
1829	MORSE RESERVOIR	0.08-	3.325	473.222	56.167	15.000	0.00-
1836	WAWASEE LAKE	0.012	0.210	384.500	5.000	14.600	0.003
1837	WEBSTER LAKE	0.025	0.790	431.000	11.500	15.000	0.005
1839	WHITEWATER LAKE	0.08-	1.620	470.167	33.0-3	15.000	0.012
1840	WINONA LAKE	0.035	1.250	466.667	11.211	15.000	0.011
1841	WESTLER LAKE	0.035	0.860	427.125	10.712	15.000	0.013
1842	WITMER LAKE	0.035	0.900	440.333	11.917	15.000	0.011
1843	LAKE MAXINKUCKEE	0.020	0.220	400.400	5.483	15.000	0.003
1844	TIPPECANOE LAKE	0.01-	0.195	391.500	5.050	15.000	0.005
1845	DALLAS LAKE	0.02-	0.830	413.333	10.067	15.000	0.01-
1846	OLIN LAKE	0.012	1.460	403.333	4.867	14.900	0.003
1847	OLIVER LAKE	0.00-	0.920	392.000	3.767	14.800	0.00-
1848	SYLVAN LAKE	0.170	0.130	444.833	47.480	14.800	0.017
1849	MOVEY LAKE	0.052	1.050	489.333	84.267	7.600	0.02-
1850	VERSAILLES LAKE	0.13-	1.090	482.000	25.07-	14.500	0.01-
1851	BASS LAKE	0.0-0	0.250	471.375	29.367	7.000	0.012
1852	CROOKED LAKE	0.01-	0.120	410.111	5.57-	15.000	0.005
1853	LAKE JAMES	0.01-	0.190	352.---	4.856	15.000	0.005
1854	LONG LAKE	0.20-	1.920	442.667	16.100	15.000	0.150
1855	PIGEON LAKE	0.05-	1.--5	442.667	11.900	15.000	0.015
1856	MARSH LAKE	0.093	0.270	451.333	34.467	15.000	0.055
1857	HAMILTON LAKE	0.033	0.720	413.167	17.450	15.000	0.01-

PERCENT OF LAKES WITH HIGHER VALUES (NUMBER OF LAKES WITH HIGHER VALUES)

LAKE CODE	LAKE NAME	MEDIAN TOTAL P	MEDIAN INORG N	500-MEAN SEC	MEAN CHLORA	15-MIN DO	MEDIAN DISS ORTHO P	INDEX NO
1805	CATARACT LAKE	37 (9)	15 (4)	31 (8)	62 (16)	35 (0)	37 (9)	217
1811	GEIST RESERVOIR	27 (7)	35 (9)	15 (4)	12 (3)	92 (24)	62 (16)	243
1817	JAMES LAKE	73 (19)	42 (11)	58 (15)	50 (13)	35 (0)	65 (17)	323
1827	MISSISSINEWA RESERVOIR	12 (3)	4 (1)	8 (2)	38 (10)	35 (0)	8 (2)	105
1828	MONROE RESERVOIR	67 (17)	69 (18)	54 (14)	73 (19)	35 (0)	69 (18)	367
1829	MORSE RESERVOIR	23 (6)	0 (0)	12 (3)	4 (1)	35 (0)	58 (15)	132
1836	WAWASEE LAKE	94 (24)	85 (22)	96 (25)	88 (23)	85 (22)	98 (25)	546
1837	WEBSTER LAKE	67 (17)	62 (16)	62 (16)	54 (14)	35 (0)	81 (21)	361
1839	WHITEWATER LAKE	19 (5)	19 (5)	23 (6)	19 (5)	35 (0)	42 (11)	157
1840	WINONA LAKE	50 (12)	27 (7)	38 (10)	58 (15)	35 (0)	52 (13)	260
1841	WESTLEY LAKE	50 (12)	54 (14)	65 (17)	65 (17)	35 (0)	37 (9)	306
1842	WIMER LAKE	50 (12)	50 (13)	50 (13)	42 (11)	35 (0)	52 (13)	279
1843	LAKE MAXINUCKEE	77 (20)	81 (21)	85 (22)	85 (22)	35 (0)	96 (25)	461
1844	TIPPECANOE LAKE	85 (22)	88 (23)	92 (24)	77 (20)	35 (0)	85 (22)	462
1845	DALLAS LAKE	62 (16)	58 (15)	69 (18)	69 (18)	35 (0)	31 (8)	324
1846	OLIN LAKE	94 (24)	23 (6)	81 (21)	92 (24)	73 (19)	92 (24)	455
1847	OLIVER LAKE	100 (26)	46 (12)	88 (23)	100 (26)	79 (20)	88 (23)	501
1848	SYLVAN LAKE	4 (1)	96 (25)	27 (7)	8 (2)	79 (20)	23 (6)	237
1849	MOVEY LAKE	31 (8)	38 (10)	0 (0)	0 (0)	96 (25)	12 (3)	177
1850	VERSAILLES LAKE	8 (2)	31 (8)	4 (1)	27 (7)	88 (23)	15 (4)	173
1851	BASS LAKE	42 (11)	77 (20)	19 (5)	23 (6)	100 (26)	46 (12)	307
1852	CROOKED LAKE	81 (21)	100 (26)	77 (20)	81 (21)	35 (0)	75 (19)	449
1853	LAKE JAMES	88 (23)	92 (24)	100 (26)	96 (25)	35 (0)	75 (19)	486
1854	LONG LAKE	0 (0)	12 (3)	44 (11)	35 (9)	35 (0)	0 (0)	126
1855	PIGEON LAKE	37 (9)	8 (2)	44 (11)	46 (12)	35 (0)	27 (7)	197
1856	MARSH LAKE	15 (4)	73 (19)	35 (9)	15 (4)	35 (0)	4 (1)	177
1857	HAMILTON LAKE	58 (15)	65 (17)	73 (19)	31 (8)	35 (0)	19 (5)	281

LAKES RANKED BY INDEX NOS.

RANK	LAKE CODE	LAKE NAME	INDEX NO
1	1836	WAWASEE LAKE	546
2	1847	OLIVER LAKE	501
3	1853	LAKE JAMES	486
4	1844	TIPPECANOE LAKE	462
5	1843	LAKE MAXINKUCKEE	461
6	1846	OLIN LAKE	455
7	1852	CROOKED LAKE	449
8	1828	MONROE RESERVOIR	367
9	1837	WEBSTER LAKE	361
10	1845	DALLAS LAKE	324
11	1817	JAMES LAKE	323
12	1851	BASS LAKE	307
13	1841	WESTLER LAKE	306
14	1857	HAMILTON LAKE	281
15	1842	WITHER LAKE	279
16	1848	WINONA LAKE	260
17	1811	GEIST RESERVOIR	243
18	1848	SYLVAN LAKE	237
19	1885	CATARACT LAKE	217
20	1855	PIGEON LAKE	197
21	1856	MARSH LAKE	177
22	1849	HOVEY LAKE	177
23	1850	VERSAILLES LAKE	173
24	1839	WHITEWATER LAKE	157
25	1829	MORSE RESERVOIR	132
26	1854	LONG LAKE	126
27	1827	MISSISSINEWA RESERVOIR	105

APPENDIX B

CONVERSION FACTORS

CONVERSION FACTORS

Hectares x 2.471 = acres

Kilometers x 0.6214 = miles

Meters x 3.281 = feet

Cubic meters x 8.107×10^{-4} = acre/feet

Square kilometers x 0.3861 = square miles

Cubic meters/sec x 35.315 = cubic feet/sec

Centimeters x 0.3937 = inches

Kilograms x 2.205 = pounds

Kilograms/square kilometer x 5.711 = lbs/square mile

APPENDIX C

TRIBUTARY FLOW DATA

TRIBUTARY FLOW INFORMATION FOR INDIANA 03/29/76

LAKE CODE 1847 OLIVER LAKE

TOTAL DRAINAGE AREA OF LAKE(SQ KM) 28.7

TRIBUTARY	SUB-DRAINAGE AREA(SQ KM)	NORMALIZED FLOWS(CMS) JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	MEAN
1847A1	28.7	0.337	0.411	0.592	0.549	0.351	0.269	0.161	0.054	0.051	0.054	0.142	0.263	0.269
184781	5.7	0.062	0.079	0.119	0.110	0.068	0.054	0.031	0.008	0.009	0.009	0.028	0.054	0.052
1847C1	15.0	0.173	0.215	0.311	0.286	0.184	0.142	0.085	0.025	0.026	0.026	0.074	0.139	0.140
1847Z2	6.5	0.071	0.091	0.136	0.125	0.079	0.062	0.037	0.010	0.010	0.010	0.031	0.062	0.060

SUMMARY

TOTAL DRAINAGE AREA OF LAKE = 28.7
SUM OF SUB-DRAINAGE AREAS = 27.2
TOTAL FLOW IN = 3.04
TOTAL FLOW OUT = 3.23

MEAN MONTHLY FLOWS AND DAILY FLOWS(CMS)

TRIBUTARY	MONTH	YEAR	MEAN FLOW	DAY	FLOW	DAY	FLOW	DAY	FLOW
1847A1	6	73	0.453	9	0.680				
	7	73	0.311	14	0.311				
	8	73	0.204	12	0.184				
	9	73	0.119	8	0.130				
	10	73	0.096	6	0.105				
	11	73	0.102	10	0.088				
	12	73	0.261	8	0.170				
	1	74	0.453	5	0.396				
	2	74	0.566	9	0.623	23	0.680		
	3	74	0.680	9	0.906	23	0.623		
	4	74	0.481	13	0.566				
	5	74	0.453	11	0.368				
184781	6	73	0.091	9	0.133				
	7	73	0.059	14	0.062				
	8	73	0.045	12	0.042				
	9	73	0.031	8	0.034				
	10	73	0.025	6	0.028				
	11	73	0.028	10	0.025				
	12	73	0.054	8	0.040				
	1	74	0.091	5	0.082				
	2	74	0.110	9	0.127	23	0.133		
	3	74	0.136	9	0.176	23	0.122		
	4	74	0.096	13	0.113				
	5	74	0.088	11	0.076				

TRIBUTARY FLOW INFORMATION FOR INDIANA 03/29/76

LAKE CODE 1847 OLIVER LAKE

MEAN MONTHLY FLOWS AND DAILY FLOWS(CMS)

TRIBUTARY	MONTH	YEAR	MEAN FLOW	DAY	FLOW	DAY	FLOW	DAY	FLOW
1847C1	6	73	0.238	9	0.340				
	7	73	0.156	14	0.164				
	8	73	0.119	12	0.113				
	9	73	0.082	8	0.091				
	10	73	0.068	6	0.074				
	11	73	0.074	10	0.068				
	12	73	0.142	8	0.105				
	1	74	0.238	5	0.215				
	2	74	0.283	9	0.340	23	0.340		
	3	74	0.368	9	0.453	23	0.311		
	4	74	0.255	13	0.283				
	5	74	0.232	11	0.201				
1847ZZ	6	73	0.102	9	0.150				
	7	73	0.068	14	0.071				
	8	73	0.051	12	0.048				
	9	73	0.034	8	0.040				
	10	73	0.028	6	0.031				
	11	73	0.031	10	0.028				
	12	73	0.062	8	0.045				
	1	74	0.102	5	0.093				
	2	74	0.125	9	0.144	23	0.150		
	3	74	0.156	9	0.198	23	0.139		
	4	74	0.110	13	0.127				
	5	74	0.099	11	0.085				

APPENDIX D

PHYSICAL and CHEMICAL DATA

STORET RETRIEVAL DATE 76/03/30

184701
41 34 17.0 085 24 15.0 3
OLIVER LAKE
18087 INDIANA

11EPALES 2111202
0074 FEET DEPTH CLASS 00

DATE FROM TO	TIME OF DAY	DEPTH FEET	00010 WATER TEMP CENT	00300 DO MG/L	00077 TRANSP SECCHI INCHES	00094 CNDUCTVY FIELD MICROMHO	00400 PH SU	00410 T ALK CACO3 MG/L	00610 NH3-N TOTAL MG/L	00625 TOT KJEL N MG/L	00630 NO2&NO3 N-TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P
73/05/04	11 30	0000	11.7		132	450	8.10	184	0.040	0.300	1.010	0.002K
	11 30	0006	11.4	10.7		440	8.50	183	0.040	0.300	1.000	0.002K
	11 30	0015	11.4	10.7		440	8.40	182	0.040	0.300	0.990	0.002K
	11 30	0025	11.4	10.6		440	8.40	181	0.040	0.300	0.990	0.002K
	11 30	0040	10.0	10.5		410	8.30	181	0.040	0.300	0.990	0.002K
	11 30	0055	8.5	9.8		410	8.20	189	0.050	0.300	0.990	0.002K
	11 30	0070	8.4	9.9		440	8.30	182	0.060	0.300	0.990	0.002K
73/08/06	09 30	0000	24.7		72	402	8.40	156	0.100	0.800	0.790	0.005
	09 30	0005	24.7	8.2		402	8.40	158	0.040	0.400	0.720	0.003
	09 30	0015	23.2	8.2		392	8.10	159	0.070	0.400	0.770	0.002
	09 30	0025	13.9	6.2		352	7.70	185	0.060	0.300	0.990	0.004
	09 30	0040	9.7	3.8		318	7.60	186	0.050	0.200	0.940	0.003
	09 30	0055	7.6	1.8		301	7.60	185	0.060	0.200	1.000	0.004
	09 30	0075	7.0	1.0		298	7.40	188	0.060	0.300	0.870	0.005
73/10/11	15 45	0000	19.3	9.2	120	355	8.50	145	0.050	0.600	0.550	0.014
	15 45	0015	19.1	9.4		354	8.40	146	0.030	0.400	0.560	0.013
	15 45	0025	16.1	6.6		350	8.10	153	0.050	0.400	0.630	0.012
	15 45	0035	10.3	1.2		327	7.50	179	0.040	0.500	0.870	0.015
	15 45	0045	9.0	0.4		316	7.40	179	0.040	0.400	0.830	0.014
	15 45	0055	7.9	0.2		306	7.40	176	0.060	0.400	0.800	0.014
	15 45	0065	7.3	0.4		301	7.30	180	0.160	0.500	0.550	0.013
	15 45	0080	7.0	0.4		303	7.30	187	0.400	0.900	0.240	0.014

K VALUE KNOWN TO BE
LESS THAN INDICATED

STORET RETRIEVAL DATE 76/03/30

184701
41 34 17.0 085 24 15.0 3
OLIVER LAKE
18087 INDIANA

11EPALES 2111202
0074 FEET DEPTH CLASS 00

DATE FROM TO	TIME OF DAY	DEPTH FEET	00665 PHOS-TOT MG/L P	32217 CHLRPHYL A UG/L
73/05/04	11 30	0000	0.007	2.7
	11 30	0006	0.008	
	11 30	0015	0.007	
	11 30	0025	0.009	
	11 30	0040	0.007	
	11 30	0055	0.006	
	11 30	0070	0.007	
73/08/06	09 30	0000	0.011	5.2
	09 30	0005	0.008	
	09 30	0015	0.008	
	09 30	0025	0.009	
	09 30	0040	0.009	
	09 30	0055	0.009	
	09 30	0075	0.016	
73/10/11	15 45	0000	0.017	3.4
	15 45	0015	0.013	
	15 45	0025	0.012	
	15 45	0035	0.017	
	15 45	0045	0.019	
	15 45	0055	0.017	
	15 45	0065	0.014	
	15 45	0080	0.018	

APPENDIX E

TRIBUTARY DATA

STORET RETRIEVAL DATE 76/03/30

1847A1
41 34 10.0 085 24 55.0 4
OLIVER LK OUTLET
18 7.5 OLIVER LAKE
0/OLIVER LAKE
50 E RD BRDG JUST W OF LAKE
11EPALES 2111204
0000 FEET DEPTH CLASS 00

DATE FROM TO	TIME OF DAY	DEPTH FEET	00630 NO2&NO3 N-TOTAL MG/L	00625 TOT KJEL N MG/L	00610 NH3-N TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P	00665 PHOS-TOT MG/L P
73/06/09	12	35	0.850	0.780	0.019	0.005K	0.010
73/07/14	11	25	0.670	0.780	0.061	0.005K	0.005K
73/08/12	12	30	0.540	0.680	0.040	0.008	0.010
73/09/08			0.430	0.500	0.025	0.005K	0.010
73/10/06	11	45	0.420	1.500	0.042	0.005K	0.005K
73/11/10	11	30	0.460	0.650	0.096	0.005K	0.010
73/12/08	11	10	0.552	0.500	0.068	0.005K	0.015
74/01/05	11	00	0.710	0.300	0.020	0.008	0.010
74/02/09	11	45	0.840	0.400	0.020	0.005K	0.005K
74/02/23	11	00	0.950		0.045	0.010	
74/03/09	11	15	1.040	1.300	0.050	0.005	0.035
74/03/23	11	30	1.100	0.650	0.015	0.005K	0.015
74/04/13	11	00	1.010	1.100	0.025	0.005K	0.015
74/05/11			0.980	0.700	0.020	0.005K	0.025

K VALUE KNOWN TO BE
LESS THAN INDICATED

STORET RETRIEVAL DATE 76/03/30

184781
41 34 40.0 085 24 55.0 4
DOVE CREEK
18 7.5 OLIVER LAKE
T/OLIVER LAKE
450 S RD BRDG JUST E OF JCT WITH 50 E RD
11EPALES 2111204
0000 FEET DEPTH CLASS 00

DATE FROM TO	TIME OF DAY	DEPTH FEET	00630 NO2&NO3 N-TOTAL MG/L	00625 TOT KJEL N MG/L	00610 NH3-N TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P	00665 PHOS-TOT MG/L P
73/06/09	10 55		0.530	1.200	0.062	0.019	0.050
73/07/14	10 00		0.037	1.215	0.038	0.013	0.037
73/08/12	11 00		0.012	0.630	0.013	0.025	0.050
73/09/08	09 35		0.022	2.750	0.079	0.005K	0.035
73/10/06	10 53		0.010K	0.540	0.022	0.006	0.020
73/11/10	10 00		0.380	0.350	0.020	0.005K	0.010
73/12/08	09 45		3.400	0.800	0.056	0.008	0.015
74/01/05	09 30		6.200	1.000	0.092	0.012	0.020
74/02/09	10 30		3.800	0.800	0.075	0.010	0.015
74/02/23	10 30		6.800	1.250	0.060	0.055	0.080
74/03/09	10 40		4.400	1.800	0.070	0.030	0.085
74/03/23	10 30		2.400	0.900	0.030	0.005	0.025
74/04/13	10 00		1.760	1.600	0.080	0.010	0.010
74/05/11			0.600	0.800	0.040	0.005	0.035

K VALUE KNOWN TO BE
LESS THAN INDICATED

STORET RETRIEVAL DATE 76/04/07

1846A1 and 1847C1
41 33 55.0 085 23 48.0 4
OLIVER-OLIN LAKE CONNECTION
18 7.5 OLIVER LAKE
O/OLIN LAKE
BANK SAMPLE-APPROACH FROM LIMBERLOST CAM
11EPALES 2111204
0000 FEET DEPTH CLASS 00

DATE FROM TO	TIME OF DAY	DEPTH FEET	00630 NO2&NO3 N-TOTAL MG/L	00625 TOT KJEL N MG/L	00610 NH3-N TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P	00665 PHOS-TOT MG/L P
73/06/09	13 30		1.400	0.700	0.011	0.005K	0.010
73/07/14	10 45		1.280	0.980	0.029	0.005K	0.005K
73/08/12	12 00		1.000	0.750	0.018	0.008	0.010
73/09/08	10 10		0.880	0.840	0.024	0.005K	0.005K
73/10/06	11 00		0.890	0.660	0.013	0.005K	0.010
73/11/10	10 20		1.010	0.600	0.036	0.005K	0.010
73/12/08	10 10		0.800	0.800	0.120	0.005K	0.015
74/01/05	10 15		0.910	0.500	0.080	0.016	0.016
74/02/09	11 00		1.010	1.300	0.045	0.005	0.030
74/02/23	10 45		0.940	0.600	0.020	0.005	0.015
74/03/09	10 50		1.360	1.300	0.035	0.010	0.045
74/03/23	10 45		1.510	1.500	0.030	0.005	0.015
74/04/13	10 15		1.090	1.850	0.035	0.005	0.015
74/05/11			1.040	0.700	0.035	0.005	0.020

K VALUE KNOWN TO BE
LESS THAN INDICATED